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# The Hot State Combination of Glass and Ceramics

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## Introduction

In 2009, Jessamy Kelly completed her practice-led PhD at the University of Sunderland which investigated the feasibility of combining glass and ceramics in a hot state in studio practice. She will present the results of her research at the *GLASSAC 2011 Conference*.

The starting point for this research project was to develop a model for others in the field that would expand the creative potential of combining glass and ceramics in studio practice. Glass and ceramics are generally viewed by craft practitioners as two separate disciplines, which are rarely combined in studio practice as most practitioners prefer to focus on just one discipline. A small number of artists have been found that work in both glass and ceramics, however, it became apparent that their results were not always successful as incompatibility in the materials surfaces were visible in the form of stresses and cracks. The majority of artists who combine glass and ceramics do so in a cold state to avoid these compatibility issues. It was also evident that glass and ceramics were not often combined in studio practice, which was indicated by the scarcity of artworks that combine glass and ceramics, only forty-three artists were found that work or have worked in both materials. Before this research project was carried out, there were significant gaps in the existing knowledge, understanding and practice of combining glass and ceramics in a hot state within studio practice. It was also evident that there was little literature directly related to the hot state combination of glass and ceramics. Problems relating to definition and theory, as well as practical processing techniques; demonstrated a need to enhance studio practice within this specialist field. The main practical disadvantages associated with the combined processing of glass and ceramics in a hot state, are:

- The structural differences of glass and ceramics related to their varying rates of expansion which creates incompatibility, in the form of excessive cracks/stresses in the combined body.
- The difficulty of controlling the process of partial conversion of either material into the other which would involve high refractory temperatures and specialised equipment.

It was established that many artists avoid these issues by combining the two materials in a cold state by gluing or juxtaposing them to create a perceived fit. It was the goal of this research project to address and challenge this way of working by purposefully combining the two materials in a hot state and by making technical and visual improvements, in order to aid new insights into this artistic approach.

## Material Testing

Glass and ceramics have many related material qualities and can be processed in similar ways. Chemically they are alike, however they are structurally very different; as ceramic is crystalline (composed of crystals) and glass is non-crystalline. This creates serious compatibility issues in terms of expansion and shrinkage rates when they are combined. Through controlled processing, material properties can alter when each is partially converted into the other. It is recognised by artists in the field of studio ceramics that porcelain and bone china can partially convert into a glassy form when high fired to create a translucent material [1]. This is evident in the work of leading contemporary ceramicists such as Peter Lane, Angela Mellor and Sasha Wardell who exploit translucency in their work [2]. Likewise it is recognised in the field of industrial engineering that glass can partially convert into a ceramic form when processed in a controlled way to create a glass-ceramic material [3]. This is a controlled process of

crystallisation and creates materials which have low or negative coefficient of expansion making them shock resistant and suitable for use in cookware, radomes, telescope mirrors and insulators. If not prepared with a controlled temperature schedule this process is known as devitrification which creates an unstable form of glass ceramics, with visible cracks and stresses [4]. There was no evidence found of glass-ceramic materials or processes being exploited by studio practitioners. From the outset it became apparent that the study would be directed by the capabilities of the studio practitioner within a studio environment. It was therefore decided that the production of glass-ceramics was outside of the parameters of this research. This was due to the specialist material science equipment needed to facilitate such an enquiry; the high temperatures and controls required to create glass ceramics are beyond the provision of a studio environment. This research project was conducted using viable studio materials and processing techniques only.

As a starting point, initial tests were carried out to locate the parameters of the research and to plot potential process routes. Following this, more in depth testing was required in order to resolve difficulties that arose in processing and firing. To measure the practicality and aesthetic output of the research, a range of forms and surface effects were created using the potential process routes which were then applied to a series of artworks. Compatibility studies were carried out on a series of clay bodies to establish which body was closest to the expansion rate of glass. This information was then used to select the most suitable clay body for the research project. Further tests were also carried out into the addition of quartz silica sand which was added to the porcelain and bone china clay bodies to improve the materials fit with glass. It was established that bone china was the most suitable clay body found for combining glass and ceramics in a hot state.

The clay body was set as the variable and given the known translucency and glassy phases present in porcelain and bone china; these bodies were selected. *Philips* furnace studio glass were taken as the constant blown glass to be used with the *Gaffer* blowing rods and powdered frits (which are used to colour the *Philips* Furnace) widely used by glass artists and hot glass studios. Additionally, the *Gaffer* casting glass billets and frit were taken as the constant casting glass commonly used by kiln casting glass artists. The rationale for the initial testing phase was to identify key studio processing techniques which combined glass and ceramics in a hot state, which could be readily applied by studio practitioners in the field. These process routes were then tested in order to demonstrate and address the compatibility issues associated with the combination of glass and ceramics within studio practice. A range of existing clay bodies were identified and those which matched (as closely as possible) the expansion rate of the studio glass were selected. These clay bodies were then altered by adding quartz to enhance and improve the compatibility of the materials. These clay bodies were then tested using the viable hot state processing routes in order to demonstrate how the compatibility issues had been addressed. The objective of the testing phase was to create in a hot state combined glass and ceramic samples, which retain a compatible coherent whole without excessive cracks or stresses. This was viewed as an acceptable criterion for a successful test, in line with the primary objective of the research. Practical tests were undertaken to locate viable hot state processing routes which combine glass and ceramics in studio practice.

Through the initial testing phase, it became apparent that the research required compatibility studies to be introduced in order to understand the differences in expansion rates between the ceramics and glass. Taking into account the surface stresses and cracks that were occurring in the glassy surface, it was construed that the ceramic would need to be altered in order to match the thermal expansion of the glass. The glass remained as the constant and the ceramic became the variable. A suitable clay body needed to be either found or formulated; these observations led the research to the second phase of material testing which was concerned with compatibility studies to

improve the practical application of the initial material testing. The starting point for the second phase of material testing was to discover which clay body would be compatible with the *Philips* Furnace glass and the *Gaffer* blowing and casting glass, when mixed in a hot state. The selection of a compatible clay body which was accommodating and tolerant was essential to the success of this research project. If a suitable body was not found it would have been necessary to create a new body that was tailored to the research requirements i.e. a compatible ceramic body that will accommodate a glass, within a 10% difference of expansion. This would have been a difficult process and would have pushed the research beyond its time frame. Close examination of a series of clay bodies, was led by focused testing of these potential clay bodies. Data on the expansion rates of the materials used in this research study were documented and analysed which helped with the comparison of the different clay bodies. From this initial analysis it became apparent that the *Pottery Crafts* bone china ( $85.4 \times 10^{-7}$ ) was closest to the *Philips* furnace glass ( $96 \times 10^{-7}$ ) and the *Gaffer* blowing ( $96 \times 10^{-7}$ ) and the *Gaffer* casting glass ( $92 \times 10^{-7}$ ) expansion rates. These rates were almost 10% in difference, which as a rule of thumb meant that they were close enough to fit in terms of compatibility.

In order to improve the compatibility of the selected clay bodies with glass, a series of tests were carried out which varied the amount of quartz to be added to the clay bodies. Quartz silica sand is a glass former commonly used in porcelain, it has a very high melting point (around  $1710^{\circ}\text{C}$ ) so it must be used with a flux. If too much quartz is present, the porcelain may crack, whereas too little may lead to crazing problems in glazes [5]. The presence of quartz and cristobalite can increase the expansion rate of a clay body during firing which can cause tension build up within thick or large scale pieces. Usually practitioners try to control and reduce the amount of quartz and cristobalite to avoid these issues. The addition of quartz to the ceramic body can be added to intentionally increase the expansion rate of the body to match the rate of the glass [6].

Quartz was therefore added intentionally to increase the expansion rate of the clay body in order to match the rate of the glass; through testing an optimum quantity of quartz was identified. Filler materials such as quartz, as previously discussed are commonly added to a clay body. However, quartz increases the expansion rate of the ceramic which weakens the body making it unsuitable to make sculptures with and should not be used to make large tiles and complex pieces [7]. This implies that bodies with the addition of quartz will not be suitable for working with complex sculptural pieces. This was an important factor to consider as this ruled out certain designs and forms that could be created and which could inhibit the creative process. Further tests with burn out paper pulp to improve the clay structure were carried out to try and improve the materials strength. The bone china body with added quartz was successfully applied to the processing routes.

## **Artworks**



To demonstrate the creative possibilities of the processing routes, a range of artworks were developed in order to position the work in a professional context within the field of glass and ceramics (see Fig. 1 & Fig. 2). Key elements of the testing were created on a larger scale in the production of final exhibition artworks. By building on the tests which showed promise and trying out different production methods, it was possible to make artworks that

realised the visual qualities of the tests. Many of the artworks were shown in exhibitions, which enabled the research results to be viewed in a professional way elucidating the impact of the emerging artworks on the field. An interest in the visual relationship between glass and ceramics and the complimentary qualities these materials embody has guided this artistic enquiry. This has been further influenced by the process of experimentation and discovery that has inspired and driven the research forward. By working with key elements of the testing phase such as the translucent and transparent effects of the materials, it was possible to draw the processes together to create a synthesis of surface texture and form. The artworks have also been influenced by the combined histories of glass and ceramics, from the initial enquiries of alchemy to the industrialisation of the materials as leading decorative mediums, to the development of glass and ceramics within the broader context of the studio craft movements.

Fig. 1: Kelly, J. (2009). 'Spliced II' White & Clear (detail). Photographer: David Williams.

The original contribution to knowledge, which this research project offers to the field of glass and ceramics; has been the successful hot state combination of glass and ceramics in a studio context. This was demonstrated through a range of process routes which display a wide range of visual qualities and practical attributes, which have been proven to be relevant to a range of artistic approaches. An existing commercial clay body was altered using the addition of quartz to create a new material which produces a compatible system for combining glass and ceramics in a hot state within studio practice. Using this new material, a body of artwork was created that demonstrated the creative application of this new material. Through this research project a practical model of study



was created as a resource for practitioners in the field as well as those outside of the field (such as designers and architects) who may be interested in the practical application of glass and ceramics. Finally, this research project provided a study that draws together disparate information about the field of glass and ceramics that can be used as a resource for other practitioners.

Fig. 2: Kelly, J. (2009). 'Wedge' White & Clear (detail), 40 x 30 x 20cm. Photographer: David Williams.

It has emerged that there are several areas for further research that could be studied. The creation of large scale ceramic forms created in paper clay (to strengthen the ceramic when it is combined with the glass) is currently being investigated. Further testing has also been carried out on other glasses, such as borosilicate glass to see if the improved bone china body is compatible. These tests have extended the appeal of this research project to wider audiences. Workshops with glass suppliers are being considered to demonstrate the new ceramic material and its compatibility with their glasses. These suppliers could potentially be interested in licensing the new ceramic material that has been developed. Designers and architects have also been approached to see if they would be interested in using the material in their work for industrial or architectural applications. Further collaborative projects have since been set up with other artists, working with their materials to see how they can improve the hot state combination of glass and ceramics in their work.

## Summary

In summary, this paper has introduced the creative possibilities of the hot state combination of glass and ceramics in studio practice. It has discussed the research that has been carried out as well as future research, which has since developed from this project. This has shown that the hot state combination of glass and ceramics is an active subject of interest within the field of studio glass and ceramics with further research possibilities to be studied. The future of combining glass and ceramics in studio practice can be further advanced and made accessible to wider audiences, thus improving creativity and promoting knowledge transfer within and beyond the field. Additionally, the wide reaching range of benefits that others in the field may find interesting and of benefit to their practice have been set out, which could be extended to wider audiences such as designers, architects and suppliers who may be interested in this new material that combines both glass and ceramics in a hot state to create unique visual qualities.

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